ON SARGENT CURVES FOR ARTIFICIALLY β-ACTIVE NUCLEI*

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(*Received for publication, Sept. 7, 1943*)

ABSTRACT. Sargent curves of all the known artificially made β-active nuclei together with naturally β-active nuclei have been drawn. From this Sargent plot attempt has been made to deduce the approximate spin of some nuclei of even mass-number. Further the utility of such a plot, in the study of nuclear phenomena such as nuclear isomerism which depends on spin change of the nuclei, has been pointed out.

Sargent (1933) plotted log λ against log E_{max} of all the naturally β-active nuclei and found that the points lie approximately on two lines separated by a distance of about two units on the logarithmic scale along the log λ axis. λ represents the decay constant of the nuclei and E represents the maximum energy of the emitted β-rays. Fermi's (1934) theory of β-decay provided a theoretical explanation of this experimental fact showing that the total probability of β-emission of a nucleus, *i.e.*, λ is dependent on the maximum energy of the emitted β-rays. Fermi's theory further showed that the transition probability of β-emission by the process $n \rightarrow P + \beta +$ neutrino, is dependent on the change of angular momentum or in other words spin-change say Δi of the nucleus. The probability of β-emission vanishes for all value of Δi except $\Delta i = 0$. The first Sargent curve corresponding to $\Delta i = 0$ was therefore called the allowed line. Later on it was shown that for Δi other than zero the β-emission is not completely forbidden, only the transitional probability is reduced by a factor about $(1/100)^{\Delta i}$ approximately which explains the separation of the two Sargent curves. The second line was therefore termed as the first forbidden line. Gamow and Teller (1936) considering the possibility of inversion of heavy nuclei during β-transition modified Fermi's selection rule of β-decay. According to them the permitted transitions are those for which $\Delta i = 0$. or $\Delta i = 1$.

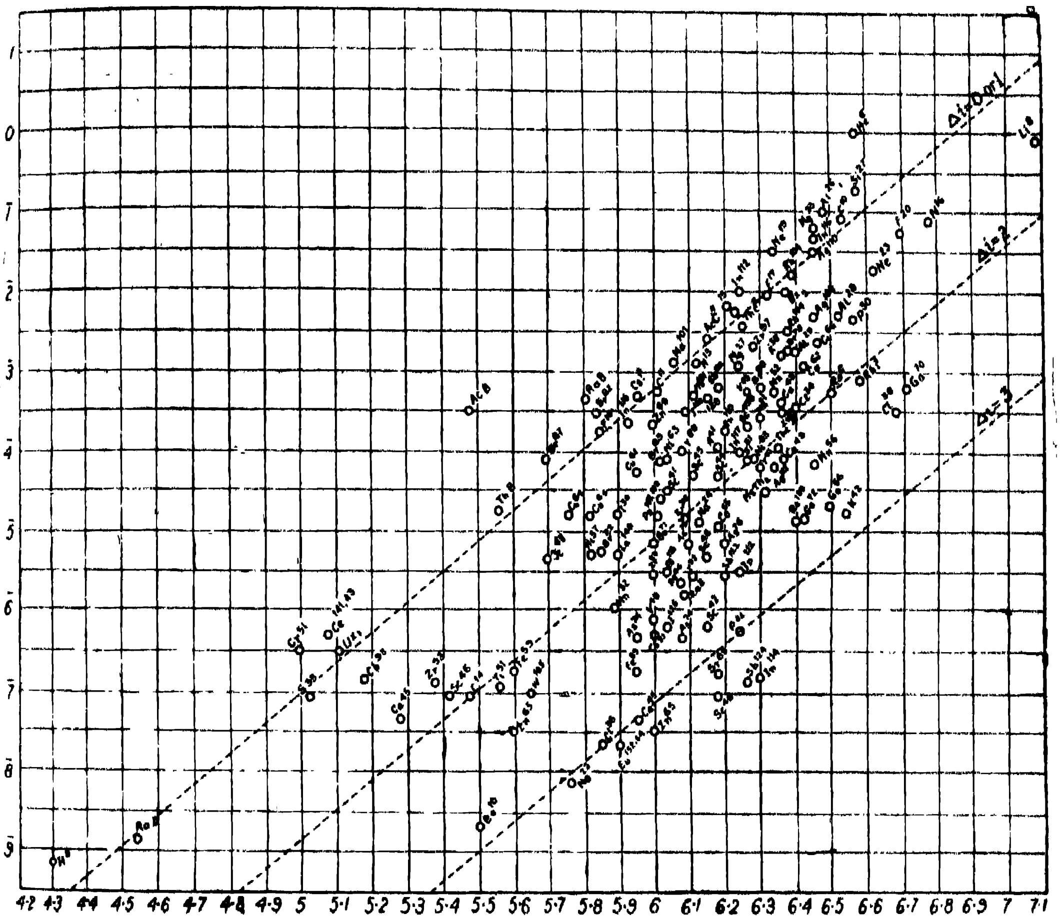
Subsequently a few artificially made β-active nuclei were plotted by Diebner and Grassmann (1938) and found to approximately fit the Sargent curves.

As stated above according to the selection rules of β-decay, the Sargent curves provide a quick method to visualise the approximate spin change of the nuclei in β-transition. I have therefore drawn the Sargent plot with all the natural and artificial β-active nuclei known up to the date as shown in the figure. The latest and the corrected value of half lives are collected from various journals and publications. All these are represented in Table I together with the spin-change Δi in β-transition as observed from the Sargent plot. Most of these

* Communicated by the Indian Physical Society.

data and the reference will be found in the Table published by Livingwood and Seaborg (1940) in Review of Modern Physics, Volume XII, 1940.

Following Gamow I have drawn three straight lines separated from each



→ Log E_{max}

other by two logarithmic units. However it must be remembered that the two lines obtained by Sargent with naturally β-active nuclei are not exactly st. lines. Further there is also considerable controversy over the positions of the forbidden lines as yet there is no satisfactory theoretical treatment of forbidden β-emission. However the first two lines are definitely proved by experimental data of naturally β-active nuclei. As Gamow and Teller selection rule of β-decay has been found to be more true than that of Fermi, it is assumed that the first line corresponds to $\Delta i=0$ or $\Delta i=1$, the second line corresponds to $\Delta i=2$ and so on. The most of the nuclei will be found to fall in the region occupied by the first and second line and some nuclei with Δi higher than two about the third line. It may be observed that the nuclei do not fall on three distinct lines. This may be partly due to the fact that the maximum energy of β-rays as determined mostly by absorption method is only approximately correct.

An important experimental fact is that nuclei having even mass numbei and even atomic number have the nuclear spin zero. This atonce suggests that for β-active nuclei of even mass number, Sargent plot shows not only the spin change Δi of the nuclei but also the actual spin of either the initial or the product nuclei. For a β-emission only increase or decrease the atomic number of the nuclei by one, but the mass number remains unchanged. Therefore if the radio-active nuclei be of even mass-number but of odd atomic number, then by β-emission the atomic number also becomes even and since the spin of nuclei having even mass-number and even atomic number is zero hence Δi gives the actual spin of the β-active nuclei. Similarly if the β-active nuclei be of even mass-number and even atomic number, its spin is initially zero and therefore gives the spin of the product nuclei which are of even mass-number but of odd atomic number. In this way as deduced from Sargent plot, the spin of some nuclei of comparatively heavy atomic number is shown in the Table II. The rest may be found out from the Table I.

TABLE I

Nuclei	T	λ	log λ	$E_{max} \times 10^{-6}$ e.v.	log E_{max}	Δi	Type
$_1H^3$	31 y	$.71 \times 10^{-9}$	$\bar{10}.8513$	.02	$\bar{4}.301$	0 or 1	
$_2He^6$	.8 sec.	.995	$\bar{1}.998$	3.7	6 568	0 or 1	β
$_3Li^8$	.88 sec.	.789	$\bar{1}.897$	12	7.079	0 or 1 or 2	
$_4Be^{10}$	10 yrs.	$.22 \times 10^{-8}$	$\bar{9}.3424$	·3	5·4771	3	β
$_5B^9$	1 m.	$.115 \times 10^{-1}$	2.061				β^+
$_5B_{12}$	02 s.	$.346 \times 10^2$	1 539	12	7.079	0 or 1	β^-
$_6C^{11}$	21	$.55 \times 10^{-3}$	4.740	1.03	6.013	0 or 1	β^+
$_6C^{14}$	89 days	$.897 \times 10^{-7}$	$\bar{8}.953$	·3	5·477	2	β^-
$_6C^{10}$	8.8 sec.	$.79 \times 10^{-1}$	$\bar{2}.897$	3.36	6.526	0 or 1	β^+
$_7N^{13}$	9.4 ms.	$.123 \times 10^{-2}$	$\bar{3}.0899$	1.2	6.0792	0 or 1	β^+
$_7N^{16}$	8.4 sec.	$.825 \times 10^{-1}$	2.916	6	6 778	0 or 1	β^-
$_8O^{15}$	2.1 ms.	$.55 \times 10^{-2}$	$\bar{3}.740$	1.7	6.230	0 or 1	β^+
$_8O^{19}$	31 s.	$.224 \times 10^{-1}$	2 350				β^-
$_9F^{17}$	74 s.	$.94 \times 10^{-2}$	$\bar{3}.973$	2.1	6.322	0 or 1	β^+
$_9F^{20}$	12	$.578 \times 10^{-1}$	2.762	5	6.699	0 or 1	β^-
$_{10}Ne^{19}$	20.3 s.	$.343 \times 10^{-1}$	$\bar{2}.535$	2.2	6.342	0 or 1	β^+
$_{11}Na^{22}$	3 y.	$.738 \times 10^{-9}$	$\bar{9}.868$	.58	5.76	3	β^+
$_{11}Na^{24}$	15 h.	$.129 \times 10^{-4}$	$\bar{5}.111$	1.36	6.133	2	β^-

TABLE I (*contd.*)

Nuclei	T	λ	log λ	$E_{max} \times 10^{-6}$ e.v.	log E_{max}	Δi	Type
$_{12}Mg^{23}$	11.6 s.	$.6 \times 10^{-1}$	2.778	2.82	6.450	0 or 1	β^+
$_{12}Mg^{24}$	10 m.	$.116 \times 10^{-2}$	3.065	1.74	6.240	0 or 1	β^-
$_{13}Al^{24}$	20 ms.	$.578 \times 10^{-3}$	$\bar{4}.762$				
$_{13}Al^{26}$	7	$.091 \times 10^{-1}$	$\bar{2}.996$	2.99	6.476	0 or 1	β^+
$_{13}Al^{28}$	2.4 ms.	$.482 \times 10^{-2}$	$\bar{3}.683$	3.3	6.518	0 or 1 or 2	
$_{13}Al^{29}$	6.7 ms.	$.173 \times 10^{-2}$	3.238	2.5	6.398	,,	β
$_{14}Si^{31}$	2.5 h.	$.77 \times 10^{-4}$	$\bar{5}.886$	1.8	6.255	2	β
$_{15}P^{30}$	2.6 ms.	$.445 \times 10^{-2}$	$\bar{3}.648$	3.6	6.556	,,	β^+
$_{15}P^{32}$	14.3 d.	$.5584 \times 10^{-6}$	$\bar{7}.7469$	1.69	6.2279	3	β
$_{16}S^{31}$	26 ms.	$.44 \times 10^{-3}$	4.6435				β^+
$_{16}S^{35}$	88 ds.	$.91 \times 10^{-7}$	$\bar{8}.9590$	.107	5.0294	0 or 1	β^-
$_{17}Cl^{33}$	2.8 sec.	.25	$\bar{1}.3979$				β^+
$_{17}Cl^{34}$	33 m.	$.34 \times 10^{-3}$	4.5315	2.5	6.3979	2	β^+
$_{17}Cl^{36}$	1 yr.	$.22 \times 10^{-7}$	$\bar{8}.3424$	.7	5.8451	3	β^-
$_{17}Cl^{38}$	37 m.	$.31 \times 10^{-3}$	$\bar{4}.4914$	4.8	6.6812	2 or 3	β
$_{18}A^{41}$	1.8 h.	$.11 \times 10^{-3}$	4.0414	1.5	6.1761	2	β^-
$_{18}A^{35}$	1.91 sec.	.36	$\bar{1}.5563$				β^+
$_{19}K^{38}$	7.7 ms.	$.15 \times 10^{-2}$	3.1761	2.3	6.3617	0 or 1 or 2	β^+
$_{19}K^{42}$	12.5 h.	$.15 \times 10^{-4}$	$\bar{5}.1761$	3.5	6.5441	3	β^-
$_{20}Ca^{45}$	180 ds.	$.44 \times 10^{-7}$	$\bar{8}.6435$	.19 .91	5.2788 5.9596	2 or 3	β^-
$_{20}Ca^{49}$	2.5 h. 30 ms	$.77 \times 10^{-4}$	$\bar{5}.8865$	2.3	6.3617	2	β^-
$_{21}Sc^{42}$	13.4 d.	$.59 \times 10^{-6}$	$\bar{7}.7704$	1.4	6.1461	3	β^+
$_{21}Sc^{43}$	4 h.	$.48 \times 10^{-4}$	5.6812	1.3	6.1139	2	β^+
$_{21}Sc^{44}$	4.1 h.	$.47 \times 10^{-4}$	$\bar{5}.6721$	1.5	6.1761	2	β^-
$_{21}Sc^{46}$	85 d.	$.94 \times 10^{-7}$	8.9731	.26 1.5	5.4150 6.1761	2 or 3	β
$_{21}Sc^{48}$	63 h.			1.1			
$_{21}Sc^{48}$	44 h.	$.44 \times 10^{-5}$	$\bar{6}.6435$	1.4 .5	6.1461 5.6990	2	β
$_{21}Sc^{49}$	57 ms.	$.2 \times 10^{-3}$	$\bar{4}.3010$	1.8	6.2553	2	β^-
$_{22}Ti^{51}$	72 d. 2.9 m.	$.11 \times 10^{-6}$	$\bar{7}.0414$	.36	5.5563	2	β^-

TABLE I (*contd.*)

Nuclei	T	λ	$\log \lambda$	$E_{max} \times 10^{6}$ e.v.	$\log E_{max}$	Δi	Type
$_{23}V^{47}$	600 ds.	$.13 \times 10^{-7}$	$\bar{8}.1139$				
$_{23}V^{48}$	16 d.	$.5 \times 10^{-6}$	$\bar{7}.9243$	1	6.0000	2 or 3	β^+
$_{23}V^{49}$	33 m.	$.35 \times 10^{-3}$	$\bar{4}.5441$	1.9	6.2788	2	β^+
$_{24}Cr^{51}$	26.5 d.	$.3 \times 10^{-6}$	$\bar{7}.4771$	.1	5.000	0 or 1	β^+
$_{24}Cr^{55}$	2.27 h.	$.85 \times 10^{-4}$	$\bar{5}.9294$				
$_{25}Mn^{51}$	46 m.	$.25 \times 10^{-3}$	$\bar{4}.3979$	2	6.3010	2	β^-
$_{25}Mn^{52}$	21.3 m.	54×10^{-3}	$\bar{4}.7324$	2.2	6.3424	2	β^+
	7.4 d.	$.11 \times 10^{-5}$	$\bar{6}.0414$	.77	5.8865	2	β^+
$_{25}Mn^{56}$	2.6 h.	$.74 \times 10^{-4}$	$\bar{5}.8692$	2.8	6.4472	2	β
$_{56}Fe^{59}$	47 d.	$.17 \times 10^{-6}$	$\bar{7}.2304$	.4 .9	5.6021 5.9542	2 3	β^-
$_{27}Co^{55}$	18h	$.11 \times 10^{-4}$	$\bar{5}.0414$	1.5	6.1761	2	β^+
$_{27}Co^{59}$	70d	$.11 \times 10^{-6}$	$\bar{7}.0414$				
$_{28}Ni^{57}$	36h	$.53 \times 10^{-5}$	$\bar{6}.7243$	.67	5.8261	2	β^+
$_{28}Ni^{65}$	2.5h	$.77 \times 10^{-4}$	$\bar{5}.8865$	1.9	6.2788	2	β^-
$_{29}Cu^{61}$	3.4h	$.57 \times 10^{-4}$	$\bar{5}.7559$	.9	5.9542	0 or 1	β^+
$_{29}Cu^{62}$	10.5m	$.11 \times 10^{-2}$	$\bar{3}.0414$	2.6	6.4150	2	β^+
$_{29}Cu^{64}$	12.8 h	$.15 \times 10^{-4}$	$\bar{5}.1761$	.66 .58	5.8195 5.7634	0 or 1 or 2	β^+ β^-
$_{29}Cu^{66}$	5m	$.23 \times 10^{-2}$	$\bar{3}.3617$	2.9	6.4624	2	β^-
$_{30}Zn^{63}$	38m	$.30 \times 10^{-3}$	$\bar{4}.4771$	2.3	6.3617	2	β^+
$_{30}Zn^{65}$	250d	$.32 \times 10^{-7}$	$\bar{8}.5058$	.4	5.6021	2 or 3	β^+
$_{30}Zn^{69}$	57ms	$.2 \times 10^{-3}$	$\bar{4}.3010$	1.0	6.000	0 or 1	β^-
$_{31}Ga^{66}$	9.4h	$.2 \times 10^{-4}$	$\bar{5}.3010$	3.1	6.4914	3	β^+
$_{31}Ga^{70}$	20m	$.57 \times 10^{-3}$	$\bar{4}.7559$	5	6.6990	2 or 3	β^-
$_{31}Ga^{72}$	14h	$.14 \times 10^{-4}$	$\bar{5}.1461$	2.6	6.4150	3	β^-
$_{33}As^{74}$	17d	$.47 \times 10^{-6}$	$\bar{7}.6721$	1.2 0.9	6.0792 5.9542	3	β^- β^+
$_{33}As^{76}$	26.8h	$.72 \times 10^{-5}$	$\bar{6}.8573$				
$_{34}Se^{79,81}$	19m	$.61 \times 10^{-3}$	$\bar{4}.7853$	1.5	6.1761	0 or 1	β
$_{35}Br^{78}$	6.4m	$.18 \times 10^{-2}$	$\bar{3}.2553$	2.3	6.3617	0 or 1 or 2	β^+
$_{35}Br^{80}$	18m	$.64 \times 10^{-3}$	$\bar{4}.8062$	2.0	6.3010	2	β^-
$_{35}Br^{82}$	34h	$.58 \times 10^{-5}$	$\bar{6}.7634$	.7	5.8451	2	β

TABLE I (*contd.*)

Nuclei	T	λ	$\log \lambda$	$E_{max} \times 10^{-6}$ e.v.	$\log E_{max}$	Δi	Type
$_{35}Br^{83}$	2.3h	$.83 \times 10^{-4}$	$\bar{5}.9191$	1.05	6.0212	0 or 1 or 2	β^-
$_{37}Rb$	17m	$.68 \times 10^{-3}$	$\bar{4}.8325$				β^-
$_{37}Rb$	15.4m	$.75 \times 10^{-3}$	$\bar{4}.8751$	3.8	6.5798	2	β^-
$_{37}Rb$	17.8m	$.61 \times 10^{-3}$	$\bar{4}.7853$	4.6	6.6628	2	β
$_{38}Sr^{87}$	2.5h	$.77 \times 10^{-4}$	$\bar{5}.8865$	.5	5.6990	0 or 1	β^-
$_{38}Sr^{89}$	55d	$.15 \times 10^{-6}$	$\bar{7}.1761$	1.5	6.1761	3	β^-
$_{39}Y^{88}$	2h	$.96 \times 10^{-4}$	$\bar{5}.9823$	1.2	6.0792	0 or 1 or 2	β^+
$_{39}Y^{92}$	70h	$.27 \times 10^{-5}$	$\bar{6}.4314$	1.3	6.1139	2	β^-
$_{40}Zr^{89}$	70h	$.27 \times 10^{-5}$	$\bar{6}.4314$	1	6.0	2	β^+
$_{40}Zr^{93}$	63d	$.127 \times 10^{-7}$	$\bar{7}.1038$	.25	5.3979	2	β^-
$_{40}Zr^{95}$	17h	$.113 \times 10^{-4}$	$\bar{5}.0531$	1.25	6.0969	2	β^-
$_{41}Cb^{92}$	11d	7.26×10^{-7}	$\bar{7}.8609$	1.0	6.000	3	β
$_{41}Cb^{93}$	55d	$.145 \times 10^{-6}$	$\bar{7}.1614$	.15	5.1761	0 or 1	β
$_{42}Mo^{91}$	17m	6.76×10^{-4}	$\bar{4}.8299$	1.85	6.2672	0 or 1 or 2	β^+
$_{42}Mo^{101}$	24m	$.493 \times 10^{-3}$	$\bar{4}.6928$	1.3	6.1139	0 or 1	β
$_{43}Ma^{101}$	9m	$.128 \times 10^{-2}$	$\bar{3}.1072$	1.16	6.0645	0 or 1	β
$_{45}Rh^{104}$	4.3m	$.267 \times 10^{-2}$	$\bar{3}.4265$	2.3	6.36	0 or 1	β^-
	42s	$.164 \times 10^{-1}$	$\bar{2}.2156$	2.3	6.36	0 or 1	
$_{47}Ag^{106}$	24.5m	$.469 \times 10^{-3}$	$\bar{4}.6712$	2.0	6.3010	2	β^+
$_{47}Ag^{108}$	2.3m	$.5 \times 10^{-2}$	$\bar{3}.6990$	2.8	6.4472	0 or 1	β^-
$_{47}Ag^{110}$	22s	$.314 \times 10^{-1}$	$\bar{2}.4969$	2.8	6.4472	0 or 1	β^-
$_{47}Ag^{112}$	3.2h	$.6 \times 10^{-4}$	$\bar{5}.7782$	2.2	6.3424	2	β^-
$_{48}Cd^{115}$	2.5d	$.329 \times 10^{-5}$	$\bar{6}.5172$	1.11	6.0453	2	β
$_{49}In^{110}$	65m	$.177 \times 10^{-3}$	$\bar{4}.2480$	1.6	6.2041	2	β^+
$_{49}In^{112}$	2.7d	$.3 \times 10^{-5}$	$\bar{6}.4771$	1.73	6.2380	3	β^-
$_{49}In^{114}$	48d	$.168 \times 10^{-6}$	$\bar{7}.2253$	1.98	6.2967	3	β^-
$_{49}In^{116}$	54ms	$.213 \times 10^{-3}$	$\bar{4}.3284$	.85	5.9294	0 or 1	β
$_{49}In^{117}$	117m	$.983 \times 10^{-4}$	$\bar{5}.9926$	1.73	6.2380	2	β^-
$_{51}Sb^{120}$	17m	$.676 \times 10^{-3}$	$\bar{4}.8299$	1.53	6.1847	0 or 1	β^+
$_{51}Sb^{122}$	2.8d	$.285 \times 10^{-5}$	$\bar{6}.4548$	1.6	6.2041	3	β^-
$_{51}Sb^{124}$	60d	$.133 \times 10^{-6}$	$\bar{7}.1239$	1.8	6.2553	3	β^-

TABLE I (*contd.*)

Nuclei	T	λ	log λ	$E_{max} \times 10^{-6}$ e.v	log E_{max}	Δi	Type
$_{53}I^{126}$	13d	$.616 \times 10^{-6}$	$\bar{7}.7896$	1.1	6.0414	3	β^-
$_{53}I^{128}$	25ms	4.6×10^{-4}	$\bar{4}.6628$	1.2, 2.1	6.0792 6.322	0 or 1 or 2	β
$_{53}I^{130}$	12.6h	1.52×10^{-5}	5.1818	.83	5.9191	2	β^-
$_{57}La^{140}$	31h	$.595 \times 10^{-5}$	$\bar{6}.7745$	.8	5.9031	2	β
$_{58}Ce^{141,43}$	15d	$.53 \times 10^{-6}$	$\bar{7}.7243$	.12	5.0792	0 or 1	β
$_{63}Eu^{152,54}$	1yr	$.219 \times 10^{-7}$	$\bar{8}.3404$				β
$_{66}Dy^{165}$	2.5h	$.767 \times 10^{-4}$	$\bar{5}.8848$	1.9	6.2788	2	β^-
Ho^{166}	30h	$.6 \times 10^{-5}$	$\bar{6}.8062$	1.6	6.2041	2 or 3	
$_{74}W^{185}$	77 days	$.104 \times 10^{-6}$	$\bar{7}.0170$	.45	5.6532	2	
$_{75}Re^{186}$	90 h	$.213 \times 10^{-5}$	$\bar{6}.3384$	1.2	6.0792	2 or 3	β
$_{75}Re^{188}$	18 h	1064×10^{-4}	$\bar{5}.0271$	2.5	6.3979	3	
$_{90}UX_1^{234}$	24.5d	$.3275 \times 10^{-6}$	$\bar{7}.5152$	0.13	5.1139	0 or 1	β
$_{91}UX_{11}^{234}$	1.14m	$.1013 \times 10^{-1}$	2.0055	2.32	6.3655	0 or 1	,,
$_{91}U2^{234}$	6.7h	$.287 \times 10^{-4}$	$\bar{5}.4579$	.6			,,
$_{82}RaB^{214}$	26.8m	$.431 \times 10^{-3}$	$\bar{4}.6345$	0.65	5.8129	0 or 1	,,
$_{83}RaC^{214}$		$.592 \times 10^{-3}$	$\bar{4}.7723$	3.15	6.4983	2	,,
$_{81}RaC''^{210}$	1.32m	$.875 \times 10^{-2}$	$\bar{3}.9420$				
$_{82}RaD^{210}$	2.5y	$.137 \times 10^{-8}$	$\bar{9}.1367$	.035	4.5441	0 or 1	,,
$_{83}RaE^{210}$	5.0d	$.16 \times 10^{-5}$	$\bar{6}.2041$	1.22	6.0864	2 or 3	,,
$_{88}MsTh_1^{228}$	6.7y	$.328 \times 10^{-8}$	$\bar{9}.5159$				
$_{89}MsTh_2^{228}$	6.13h	$.314 \times 10^{-4}$	$\bar{5}.4960$	2.05	6.3118	2	
$_{82}ThB^{212}$	10.6h	$.182 \times 10^{-4}$	$\bar{5}.2601$	.36	5.5563	0 or 1	,,
$_{83}ThC^{212}$		$.123 \times 10^{-3}$	$\bar{4}.0899$	2.25	6.3522	2	
$_{81}ThC''^{208}$	3.20m	$.361 \times 10^{-2}$	$\bar{3}.5575$	1.79	6.2529	0 or 1	
$_{89}Ac^{227}$	13.4y	$.164 \times 10^{-8}$	$\bar{9}.2148$				
$_{82}AcB^{211}$	36.0m	$.321 \times 10^{-3}$	$\bar{4}.5065$	.30	5.4771		
$_{83}AcC^{211}$		$.16 \times 10^{-4}$	$\bar{5}.2041$				
$_{81}AcC''^{207}$	4.76m	$.243 \times 10^{-2}$	$\bar{3}.3856$	1.4	6.1461	0 or 2	

Naturally Radio-active nuclei

TABLE II

Nuclei	Spin	Nuclei	Spin	Nuclei	Spin
$_{21}Sc^{42}$	3	$_{35}Br^{80}$	2	$_{49}In^{112}$	3
$_{21}Sc^{44}$	2	$_{35}Br^{82}$	2	$_{49}In^{114}$	3
$_{21}Sc^{48}$	2	$_{41}Cb^{92}$	3	$_{49}In^{116}$	0 or 1
$_{25}Mn^{52}$	2	$_{47}Ag^{106}$	2	$_{51}Sb^{120}$	0 or 1
$_{25}Mn^{56}$	2	$_{47}Ag^{108}$	0 or 1	$_{51}Sb^{122}$	3
$_{29}Cu^{66}$	2	$_{47}Ag^{110}$	0 or 1	$_{51}Sb^{124}$	3
$_{31}Ga^{66}$	3	$_{47}Ag^{112}$	2	$_{53}I^{126}$	3
$_{31}Ga^{72}$	3	$_{49}In^{110}$	2	$_{57}La^{140}$	2

TABLE III

Isomers in Sargent Curve

Nuclei	T	Emax of β ray in M.e.v.	γ-ray if emitted and Emax in M.e.v	Δi	Reference
Ca^{49}	2.5 h 30 ms	2.3 not known	.8 not known	2	Livingwood & Seaborg (1940). ,,
Rh^{104}	4.3 ms 42 s	2.3 2.3	e.055 and .08 not known	0 or 2 0 or 1	
Ti^{51}	72 d 2.8 ms	36	1.1 energy not known	2	Walke etal (1939). Walke (1937).
Mn^{52}	21.3 ms	2.2	1.2	2	Livingwood, Seaborg (1938) and Hemendinger (1939).
	7.4 d	.77	1	2	,,
Ux_2	1.14 ms	2.32	not known	0 or 1	
Uz	6.7 h	.6	,,		
Br^{82}	34 h 40 m	.7 not known	.65 not known	2	Snell (1937) and Buck (1938). Doddson and Fowler (1939).
Y^{92}	70 h 3 h	1.3 2	not known ,,	2	
In^{112}	72 s 2.7 d	not known 1.73	,, .17 and .25	3	Lawson and Cork (1937). Barnes (1939).
In^{116}	13 s	2.8	not known		Amaldi etal (1935). Cork and Lawson (1939).
	54 ms	.85	1.8 and 1.3	0 or 1	Amaldi etal and Cork and Lawson (1937).
Br^{80}	18 ms	2		2	Snell (1937). Alichanian etal (1936).
	4.4 h		$\bar{e}$		Buck (1938).
Zn^{69}	57 m 13.8 h	1.0	not known .47	0 or 1	Livingwood & Seaborg (1939). ,,

Again the Sargent plot of nuclei may be of considerable importance in the study of nuclear isomers. For according to Weizacker's (1936) theory of nuclear isomerism the initial difference in spin of the ground state and an excited metastable state is the cause of nuclear isomerism. Therefore if the spin-change Δi of the pair in β-transition is known from Sargent plot then it may give some information about the subsequent mode of decay as suggested by Hebb and Uhlenbeck (1938). In the Table III, I have collected the isomers whose existence is now well established. The value of Δi for the isomers of which decay constant and the maximum energy of the emitted β-ray is known, is also shown in the Table. As an example the isomeric pair Rh^{104} may be considered. It will be observed from the Sargent plot that Δi for both of the pair is the same and $=0$ or 1. Therefore if initially the two nuclei have large difference of spin then this large difference persists even after β-emission. Therefore if one of the pair transforms into ground state, the other will be in an excited state even after emission. According to Hebb and Uhlenbeck this excited state is destroyed by the emission of γ-rays in steps. These γ-rays again give rise to soft conversion electrons. Probability of conversion is particularly high when the difference of spin between the ground state and the excited state is high. As a matter of fact large groups of conversion electrons have been experimentally observed with Rh^{104}.

In conclusion I express my thanks to Professor M. N. Saha, F.R.S., for his interest and encouragement in the initial stage of this work. My grateful thanks are due to various workers whose experimental data I have taken. My thanks are due to Dr. D. M. Bose, Director, Bose Research Institute, for kindly permitting me to complete the work here. My thanks are also due to Dr. S. C. Sirkar for many helpful suggestions.

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REFERENCES

Alichianin, 1936, *Phys. Zeits.*
Barnes, 1939, *Phys. Rev.*, **56**, 414.
Cork and Lawson, 1919, *Phys. Rev.*, **56**, 291.
" " " 1937, *Phys. Rev.*, **52**, 531.
Diebner and Grassmann, 1938, *Phys. Zeits.*, **39**, 469.
Doddson and Fowler, 1939, *Phys. Rev.*, **55**, 880.
Fermi, 1934, *Z. f. Phys.*, **88**, 161.
Hebb and Uhlenbeck, 1933, *Physica*, **5**, 605.
Lawson and Cork, 1937, *Phys. Rev.*, **62**, 531.
Livingwood and Seaborg, 1940, *Rev. Mod. Phys.*, **12**, 35.
" " " 1938, *Phys. Rev.*, **54**, 391.
" " " 1939, *Phys. Rev.*, **55**, 457.
Sargent, 1933, *Proc. Roy. Soc. A.*, **139**, 659.
Snell, 1937, *Phys. Rev.*, **52**, 1007.
Walke, 1937, *Phys. Rev*, **52**, 777.
Amaldi etal, 1935, *Proc. Roy. Soc. A.*, **149**, 522.
Buck, 1938, *Phys. Rev.*, **54**, 1025.
Gamow and Teller, 1936, *Phys. Rev.*, **49**, 895.
Hemmendinger, 1939, *Phys. Rev.*, **55**, 604.
Walke, 1939, *Proc. Roy. Soc. A.*, **171**, 360.
Weizsacker, 1936, N. Wiss, **28**, 813.